

Dynamic and Static SQL Support

This section covers the following topics:

- General Information
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 - Preparing Natural Programs for Static Execution
 - Assembler/Natural Cross-References
 - Execution of Natural in Static Mode
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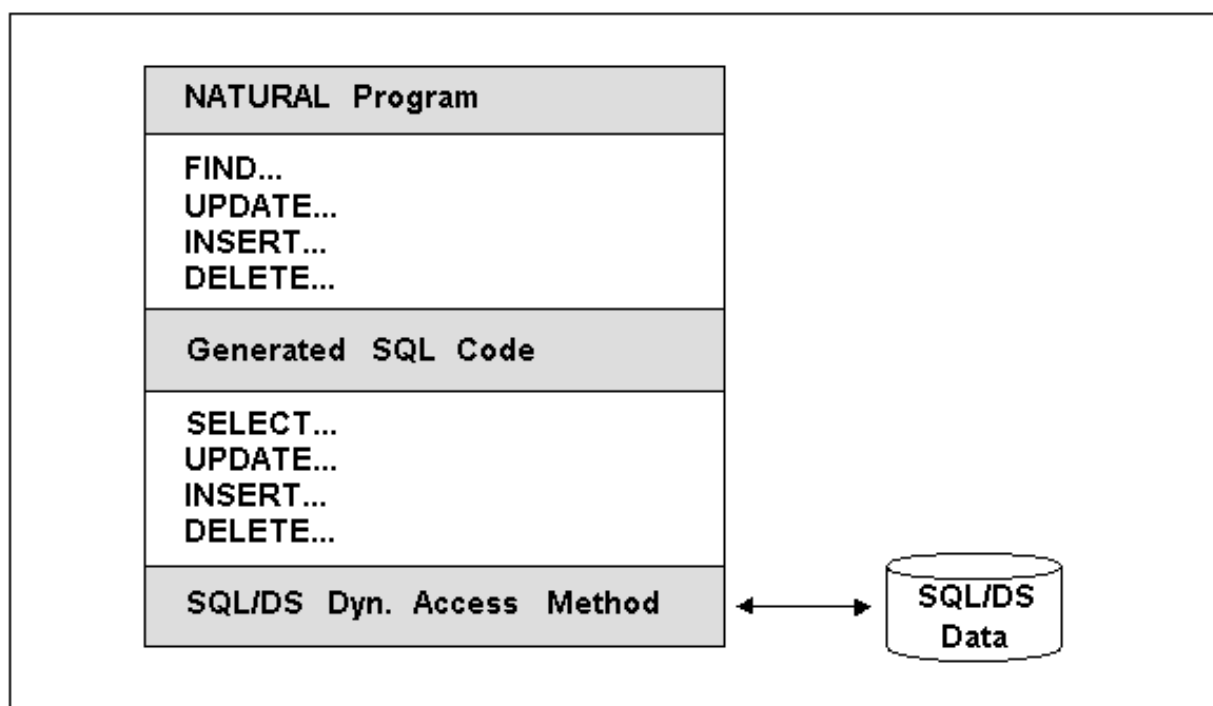
General Information

The SQL support of Natural combines the flexibility of dynamic SQL support with the high performance of static SQL support.

In contrast to static SQL support, Natural dynamic SQL support does not require any special considerations with regard to the operation of the SQL interface. All SQL statements required to execute an application request are generated automatically and can be executed immediately with the Natural system command RUN. Before executing a program, you can look at the generated SQL code, using the LISTSQL command.

Access to SQL/DS through Natural has the same form whether dynamic or static SQL support is used. Thus, with static SQL support, the same SQL statements in a Natural program can be executed in either dynamic or static mode. An SQL statement can be coded within a Natural program and, for testing purposes, it can be executed using dynamic SQL. If the test is successful, the SQL statement remains unchanged and static SQL for this program can be generated.

Thus, during application development, the programmer works in dynamic mode and all SQL statements are executed dynamically, whereas static SQL is only created for applications that have been transferred to production status.



Internal Handling of Dynamic Statements

Natural automatically provides for the preparation and execution of each SQL statement and handles the opening and closing of cursors used for scanning a table.

This section covers the following topics:

- NDBIOMO
- The Statement Table
- Processing of SQL Statements Issued by Natural

NDBIOMO

As each dynamic execution of an SQL statement requires a statically defined DECLARE STATEMENT and DECLARE CURSOR statement, a special I/O module (NDBIOMO) is provided which contains a fixed number of these STATEMENTS and CURSORS. This number is specified during the generation of NDBIOMO.

The Statement Table

If possible, an SQL statement is only prepared once and can then be executed several times if required. For this purpose, Natural internally maintains a table of all SQL statements that have been prepared and assigns each of these statements to a DECLARED STATEMENT in NDBIOMO. In addition, this table maintains the cursors used by the SQL statements SELECT, FETCH, UPDATE (positioned) and DELETE (positioned).

Each SQL statement is uniquely identified by:

- the name of the Natural program that contains this SQL statement,
- the line number of the SQL statement in this program,
- the name of the Natural library into which this program was stowed,
- the time stamp when this program was stowed.

Once a statement has been prepared, it can be executed several times with different variable values, using the dynamic SQL statement EXECUTE USING DESCRIPTOR or OPEN CURSOR USING DESCRIPTOR respectively.

When the full capacity of the statement table is reached, the entry for the next prepared statement overwrites the entry for a free statement whose latest execution is the least recent one.

When a new SELECT statement is requested, a free entry in the statement table with the corresponding cursor is assigned to it and all subsequent FETCH, UPDATE and DELETE statements referring to this SELECT statement will use this cursor. Upon completion of the sequential scanning of the table, the cursor is released and free for another assignment. While the cursor is open, the entry in the statement table is marked as used and cannot be reused by another statement.

If the number of nested FIND (SELECT) statements reaches the number of entries available in the statement table, any further SQL statement is rejected at execution time and a Natural error message is returned.

The size of the statement table depends on the size specified for NDBIOMO. Since the statement table is contained in the SQL/DS buffer area, the DB2SIZE parameter may not be sufficient and may need to be increased.

Processing of SQL Statements Issued by Natural

The embedded SQL uses cursor logic to handle SELECT statements. The preparation and execution of a SELECT statement is done as follows:

- The typical SELECT statement is prepared by a program flow which contains the following embedded SQL statements (note that *X* and *SQLOBJ* are SQL variables, not program labels, and that the question marks below are parameter markers which indicate where values are to be inserted at execution time.):

```
DECLARE SQLOBJ STATEMENT
```

```
DECLARE X CURSOR FOR SQLOBJ
```

```
INCLUDE SQLDA (copy SQL control block)
```

Then, the following statement is moved into *SQLSOURCE*:

```
SELECT PERSONNEL_ID, NAME, AGE
FROM EMPLOYEES
WHERE NAME IN (?, ?)
      AND AGE BETWEEN ? AND ?
```

```
PREPARE SQLOBJ FROM SQLSOURCE
```

- Then, the SELECT statement is executed as follows:

```
OPEN X USING DESCRIPTOR SQLDA
FETCH X USING DESCRIPTOR SQLDA
```

The descriptor *SQLDA* is used to indicate a variable list of program areas. When the OPEN statement is executed, it contains the address, length and type of each value which replaces a parameter marker in the WHERE clause of the SELECT statement. When the FETCH statement is executed, it contains the address, length and type of all program areas which receive fields read from the table. When the FETCH statement is executed for the first time, it sets the Natural system variable *NUMBER to a non-zero value if at least one record is found that meets the search criteria. Then, all records satisfying the search criteria are read by repeated execution of the FETCH statement.

- Once all records have been read, the cursor is released by executing the following statement:

```
CLOSE X
```

Preparing Natural Programs for Static Execution

Static SQL is generated in Natural batch mode for one or more Natural applications which can consist of one or more Natural object programs. The number of programs that can be modified for static execution in one run of the generation procedure is limited to 999.

During the generation procedure, the database access statements contained in the specified Natural objects are extracted, written to work files and transformed into a temporary Assembler program. If no Natural program is found that contains an SQL access or if any error occurs during static SQL generation, batch Natural terminates and condition code 40 is returned, which means that all further JCL steps should no longer be executed.

The temporary Assembler program is written to a temporary file (the Natural work file CMWKF06) and precompiled. During precompilation, a static SQL/DS package (access module) is created and after the precompilation, the precompiler output is extracted from the Assembler program and written to the corresponding Natural objects, which means that the Natural objects are modified (prepared) for static execution. The temporary Assembler program is no longer used and deleted.

Note:

Since the Assembler precompiler of SQL/DS does not support GRAPHIC field types, you cannot generate a static Assembler program if your Natural program(s) contain any references to GRAPHIC-type columns.

The Natural subprogram NDBDBRM can be used to check whether a Natural program contains an SQL access and whether it has been modified for static execution.

This section covers the following topics:

- Creating a Static SQL/DS Package under VSE/ESA
- The Generation Procedure - CMD CREATE Command
- The Modification Procedure - CMD MODIFY Command

Creating a Static SQL/DS Package under VSE/ESA

Under VSE/ESA, a static SQL/DS package is created by using the sample job I075.

The job I075 consists of the following steps:

Step 1: Generate the Static Assembler Program

- Define six Natural work files for output.
- Define as PHASE search library the library that contains the Natural batch module and the library where you installed this Natural for SQL/DS version (since the static generation process uses the Natural modules NDBSTAT and NDBCHNK).
- Define the necessary Natural commands and the Natural input for the static generation procedure.

The output (CMWKF06) consists of a temporary Assembler program which contains all the database access statements of the Natural objects involved and serves as input for the precompilation step below.

Step 2: Precompile the Generated Assembler Program

- Define as PHASE search library the library where you installed SQL/DS.
- Define the necessary precompiler options and specify your SQL user ID and password.

The precompiler output consists of a static SQL/DS package and a precompiled temporary Assembler program (IJSYSPH) which contains all the database access statements transformed from SQL into Assembler statements and serves as input for the modification step below.

Step 3: Modify the Natural Objects

- Define as PHASE search library the library that contains the Natural batch module.
- Define the necessary Natural commands and the Natural input for the object modification procedure.

The output consists of a modified Natural object which contains all required SQL/DS access information.

The Generation Procedure - CMD CREATE Command

To generate static SQL for Natural programs, LOGON to library SYSSQL.

Note:

Since a new SYSSQL library has been created when installing Natural for SQL/DS, ensure that it contains all Predict interface programs necessary to run the static SQL generation. These programs are loaded into SYSSQL during Predict installation (see the relevant Predict documentation).

Then specify the CMD CREATE command and the Natural input necessary for the static SQL generation process; the CMD CREATE command has the following syntax:

```
CMD CREATE DBRM static-name USING using-clause  
{application-name,object-name,excluded-object}...
```

The generation procedure reads but does not modify the specified Natural objects. If one of the specified programs was not found or had no SQL access, return code 4 is returned at the end of the generation step.

Static Name

If the PREDICT DOCUMENTATION option is to be used, a corresponding Predict static SQL entry must be available and the *static-name* must correspond to the name of this entry. In addition, the *static-name* must correspond to the name of the static SQL/DS package to be created during precompilation. The *static-name* can be up to 8 characters long and must conform to Assembler naming conventions.

USING Clause

The *using-clause* specifies the Natural objects to be contained in the static SQL/DS package. These objects can either be specified explicitly as INPUT DATA in the JCL or obtained as PREDICT DOCUMENTATION from Predict.

$\text{USING } \left\{ \begin{array}{l} \text{INPUT DATA} \\ \text{PREDICT DOCUMENTATION} \end{array} \right\} \left[\begin{array}{l} \text{WITH XREF } \left\{ \begin{array}{l} \text{YES} \\ \text{NO} \\ \text{FORCE} \end{array} \right\} \end{array} \right] [\text{LIB } \textit{lib-name}]$

If the parameters to be specified do not fit in one line, specify the command identifier (CMD) and the various parameters in separate lines and use both the input delimiter (as specified with the ID parameter; default is ",") and the continuation indicator (as specified with the CF parameter; default is "%") as shown in the example below.

Example:

```
CMD
CREATE,DBRM,static,USING,PREDICT,DOCUMENTATION,WITH,XREF,NO,%
LIB,library
```

Alternatively, you can also use abbreviations as shown in the following example:

Example:

```
CMD CRE DBRM static US IN DA W XR Y LIB library
```

The sequence of the parameters USING, WITH and LIB is optional.

INPUT DATA

As input data, the applications and names of the Natural objects to be included in the static SQL/DS package must be specified in the subsequent lines of the job stream (*application-name,object-name*). A subset of these objects can also be excluded again (*excluded-objects*). Objects in libraries whose name begins with "SYS" can be used for static generation, too.

The applications and names of Natural objects must be separated by the input delimiter (as specified with the ID parameter; default is ","). If you wish to specify all objects whose name begins with a specific string of characters, use an *object-name* or *excluded-objects* name that ends with asterisk notation (*). To specify all objects in an application, use asterisk notation only.

Example:

```
LIB1 , ABC*
LIB2 , A* , AB*
LIB2 , *
...
```

The specification of applications/objects must be terminated by a line that contains a period (.) only.

PREDICT DOCUMENTATION

As Predict supports static SQL for SQL/DS, you can also have Predict supply the input data for creating static SQL by using already existing PREDICT DOCUMENTATION.

WITH XREF Option

As Predict Active References supports static SQL for SQL/DS, the generated static SQL/DS package can be documented in Predict and the documentation can be used and updated with Natural.

WITH XREF is the option which enables you to store cross-reference data for a static SQL entry in Predict each time a static SQL/DS package is created (YES). You can instead specify that no cross-reference data are stored (NO) or that a check is made to determine whether a Predict static SQL entry for this static SQL/DS package already exists (FORCE). If so, cross-reference data are stored; if not, the creation of the static SQL/DS package is not allowed. For more information on Predict Active References, refer to the Predict documentation.

When WITH XREF (YES/FORCE) is specified, XREF data are written for both the Predict static SQL entry (if defined in Predict) and each generated static Natural program. However, static generation with WITH XREF (YES/FORCE) is possible only if the corresponding Natural programs have been cataloged with XREF ON.

WITH XREF FORCE only applies to the USING INPUT DATA option.

Note:

If you do not use Predict, the XREF option must be omitted or set to NO and the module NATXRF2 need not be linked to the Natural nucleus.

Library Option - LIB

With the LIB option, a Predict library other than the default library (*SYSSTA*) can be specified to contain the Predict static SQL entry and XREF data. The name of the library can be up to eight characters long.

The Modification Procedure - CMD MODIFY Command

The modification procedure modifies the Natural objects involved by writing precompiler information into the object and by marking the object header with the *static-name* as specified with the CMD CREATE command.

In addition, any existing copies of these objects in the Natural global buffer pool (if available) are deleted and XREF data are written to Predict (if specified during the generation procedure).

To perform the modification procedure, LOGON to SYSSQL and specify the CMD MODIFY command which has the following syntax:

CMD <u>MODIFY</u> [<u>XREF</u>]
--

The input for the modify step is the precompiler output which must reside on a dataset defined as the Natural work file CMWKF01.

The output consists of precompiler information which is written to the corresponding Natural objects. In addition, a message is returned telling you whether it was the first time an object was modified for static execution ("modified") or whether it had been modified before ("re-modified").

If the XREF option is specified, the Natural work file CMWKF02 must be defined to contain the resulting list of cross-reference information concerning the statically generated SQL statements (see also Assembler/Natural Cross-References).

Assembler/Natural Cross-References

If you specify the XREF option of the MODIFY command, an output listing is created on the work file CMWKF02, which contains the static SQL/DS package name and the Assembler statement number of each statically generated SQL statement together with the corresponding Natural source-code line number, program name, library name, database ID and file number.

DBRMNAME	STMTNO	LINE	NATPROG	NATLIB	DB	FNR	COMMENT	....
TESTDBRM	000627	0390	TESTPROG	SAG	010	042	INSERT	....
	000641	0430					INSERT	....
	000652	0510					SELECT	....
	000674	0570					SELECT	....
	000698	0570					SELECT 2ND	....
	000728	0650					UPD/DEL	....
	000738	0650					UPD /DEL 2ND	....
	000751	0700					SELECT	....
	000775	0700					SELECT 2ND	....

Column	Explanation
DBRMNAME	Name of the static SQL/DS package which contains the static SQL statement.
STMTNO	Assembler statement number of the static SQL statement.
LINE	Corresponding Natural source code line number.
NATPROG	Name of the Natural program that contains the static SQL statement.
NATLIB	Name of the Natural library that contains the Natural program.
DB / FNR	Natural database ID and file number.
COMMENT	Type of SQL statement.

Execution of Natural in Static Mode

To be able to execute Natural in static mode, all users of Natural must have the SQL/DS RUN privilege for the static SQL/DS package created at precompilation.

To execute static SQL start Natural and execute the corresponding Natural program. Internally, the Natural runtime interface evaluates the precompiler data written to the Natural object and then performs the static accesses.

To the user there is no difference between dynamic and static execution.

Static SQL with Natural Security

Static generation can be disallowed with Natural Security by:

- restricting access to library SYSSQL,
- disallowing the module CMD,
- restricting access to the libraries that contain the relevant Natural objects,
- disallowing one of the commands CATALOG or STOW for a library that contains relevant Natural objects.

If a library is defined in Natural Security and the DBID and FNR of this library are different from the default specifications, the static generation procedure automatically switches to the DBID and FNR specifications defined in Natural Security.

Mixed Dynamic/Static Mode

It is possible to operate Natural in a mixed static and dynamic mode where static SQL is generated for some programs.

The mode in which a program is run is determined by the Natural object program itself. If a static SQL/DS package is referenced in the executing program, all statements in this program are executed in static mode.

Note:

Natural programs which return a runtime error do not automatically execute in dynamic mode. Instead, either the error must be corrected or, as a temporary solution, the Natural program must be recataloged to be able to execute in dynamic mode.

Within the same Natural session, static and dynamic programs can be mixed without any further specifications. The decision which mode to use is made by each individual Natural program.

Messages and Codes

This section lists the error messages that may be issued during static generation.

STAT9001 Object buffer allocation failed. RC = *return code*

Expl.: Program NDBCHNK has been invoked to allocate space for Natural object load, but the allocation has failed; retry or increase the free storage pool.

STAT9002 Write on object area failed. RC = *return code*

Expl.: Program NDBCHNK has been invoked to write a Natural object row into the appropriate buffer, but the write has failed; this is probably a NDBCHNK program error.

STAT9003 Statement entry retrieve error. RC = *return code*

Expl.: Program NDBSTAT has been invoked to retrieve next SQL/DS statement information from the Natural object loaded in main storage, but the retrieval has failed (RC was neither 0 (OK) nor 4 (EOP)); the probable cause is a Natural object inconsistency.

STAT9004 Unsupported Adabas command: *command*

Expl.: Program NDBSTAT has been invoked to retrieve next SQL/DS statement information from the Natural object loaded in main storage, but the Adabas command code returned was invalid; the probable cause is a Natural object inconsistency.

STAT9005 Freemain failed. RC = *return code*

Expl.: Program NDBCHNK has been invoked to free the area allocated for Natural object load, but the release has failed; this is probably a program error.

STAT9006 Call for timestamp of program failed. RC = *return code*

Expl.: Program NDBSTAT has been invoked to know the time stamp associated to the loaded Natural object, but the call has failed; this is probably a program error.

STAT9007 A-List item retrieve failed. RC = *return code*

Expl.: Program NDBSTAT has been invoked to retrieve the next compilation A-list element, but the retrieval has failed (RC was neither 0 (OK) nor 20 (EOL)); the probable cause is a Natural object inconsistency.

STAT9009 Invalid database field format: *format*

Expl.: Program NDBSTAT has been invoked to retrieve the next compilation A-list element, but the SQL/DS format code returned is invalid; the probable cause is a Natural object inconsistency.

STAT9011 Mailbox length exceeds maximum.

Expl.: The SQL/DS precompiler parameter (mailbox length) does not fit into a halfword, which means that the SQL statement contains too many variables.

STAT9014 Warning, may indicate a problem: second select table reset.

Expl.: The table for a second selection logs the statement number of all second SELECT statements. The table is reset if there are more than 100 entries, which means with many nested program loops. If the table is reset, no second UPDATE or DELETE statements are generated.

STAT9016 Versions of NDBSTAT and SQLGEN Natural programs do not match.

Expl.: The versions of the Natural programs used for the static generation (library SYSSQL) must be the same as one of the dynamically loaded Assembler program NDBSTAT.

STAT9017 address of program program in library library not found.

Expl.: A Natural object address was not found and the object cannot be modified. Either the object was not found or the address was wrong.

STAT9019 * Warning: Natural terminates abnormally, run may continue. *****

Expl.: Natural terminates abnormally with RC=4. A Natural member was explicitly entered which does not exist or does not have SQL access. The static generation can continue.

STAT9020 Start run of SQLGEN for DBRM *dbrm*.**STAT9021 Start merging temporary datasets.****STAT9022 Precompile input *input* written to temporary dataset.**

Expl.: The temporary assembler program for the precompiler input was written to a temporary dataset (Natural work file 5).

STAT9023 * END OF DATA *******STAT9024 No program with SQL access found.**

Expl.: None of the programs processed by the CMD command accessed an SQL system.

STAT9025 Program *program* in library *library* not found.**STAT9026 DB access module names *module* and *module* do not match.**

Expl.: The module name specified with the CMD CREATE command must be the same as the name of the DBRM specified in the DBRMLIB job card of the precompilation step.

STAT9027 Error *error* purging program, library in buffer pool. Run continues.**STAT9029 Limit of *limit* NULL indicators per SQL statement exceeded.**

Expl.: The maximum number of 1500 NULL indicators per SQL statement has been exceeded.

STAT9031 XREF option "NO" and Predict DDA default "YES" do not match.

Expl.: The Predict DDA default setting for static SQL XREF is set to "YES", but the XREF option in the CMD command is set to "NO".

STAT9032 XREF option "FORCE" but no Predict documentation found.

Expl.: With the XREF option FORCE, the static generation continues and writes XREF data only if Predict documentation exists for a given DBRM. If there is no Predict documentation available, static generation is not performed.

STAT9033 No XREF data exist for member *member*.

Expl.: Either the Natural program which is to be statically generated cannot be cataloged with XREF=ON or the XREF data are not on the used Predict file.

STAT9034 XREF option "YES" or "NO" but Predict DDA default "FORCE".

Expl.: The Predict DDA default setting for static SQL XREF is set to "FORCE", but the XREF option in the CMD command is set to "NO" or "YES".

STAT9036 Given DBRM library not defined as 3GL Predict application.

Expl.: The library for the DBRM entered with the LIB option is not defined as 3GL application in Predict. Check the library name in Predict which contains the DBRM.

STAT9039 Library name must not be blank.**STAT9040 CATALOG or STOW not allowed for library *library*.**

Expl.: The commands CATALOG or STOW are not allowed in your security environment. However, the CATALOG or STOW privilege is needed for static generation.

STAT9041 Natural Security restriction. Message code: *message code***STAT9050 No Predict documentation for specified DBRM found.**

Expl.: No documentation was found in Predict for the DBRM specified with the CMD command. Either the DBRM is not documented in the used Predict file or a wrong DBRM name has been specified.

STAT9062 No Predict installed.**STAT9063 XREF interface not linked. XREF option reset, run continues.****STAT9064 XREF option not set. Predict DDA default *default* taken.**

Expl.: The Predict DDA default setting for static SQL XREF is read, because no XREF option is specified in the CMD command and the XREF interface and Predict are installed.

STAT9065 DBRM name must start with an uppercase character.**STAT9066 No Predict installed.****STAT9072 DBRM name must not be blank.****STAT9073 Invalid syntax for *parameter/option* specified.****STAT9092 Error occurred. XREF data for DBRM will be deleted.****STAT9093 Error *error* occurred in program *program* in line *line*.****STAT9094 Return code *return code* on call of *program*.****STAT9095 Error in *parameter* *parameter* on call of *program*.**